PHOTOCENSUS OF THE BLUENOSE CARIBOU HERD IN JULY 1986 AND 1987

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DEPARTMENT OF RENEWABLE RESOURCES

GOVERNMENT OF THE NORTHWEST TERRITORIES

INUVIK, NWT

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Northwest Territories Renewable Resources

File Report No. 108

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ABSTRACT

A post-calving photo census of the Bluenose caribou herd was conducted in July 1986 and 1987. Groups of caribou were located by monitoring radio-collared individuals; and if suitably aggregated they were photographed. The population estimates for 1986 and 1987 were 99,400 and 115,200 non-calf caribou, respectively. The estimates represent counts of separate aggregations photographed on 4 different days in 1986 and 3 days in 1987. Potential problems with interpretation of the counts include: 1) possible double counting as some aggregations did not occur on the same date; 2) potential photo interpretation error; and 3) animals missed that were not in radio-collared groups.

We do not feel that there was movement between the different groups at the time of our photographs based on our radio-tracking information. Photo-interpretive error is difficult to assess but one interpreter (HJR) counted approximately 4% more animals than the other observer (BM) on photos that both counted in 1986; 2% in 1987. Caribou distributed on other parts of the range were certainly missed. Confidence limits of the estimate cannot be made, but considering possible sources of error, the 1987 population estimate may be as high as 120,000 non-calf caribou. We feel that the bulk of the herd was surveyed and that the post-calving photo-census technique is appropriate for the Bluenose herd.

Future censuses will require additional caribou collaring as radio-collars expire and should have increased aircraft and manpower support. The use of vertical photography with a large format belly camera could increase the accuracy of the counts.

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INTRODUCTION

The Bluenose caribou herd is one of the major barren-ground caribou (Rangifer tarandus groenlandicus) herds in the Northwest Territories. It's range is considered to be bordered by the Mackenzie River in the west, the arctic coast in the north, the Great Bear River in the south, and approximately the Coppermine area in the east (Figure 1). Estimates of population size have been attempted since the 1950s (Kelsall and Hawley 1967), but systematic aerial surveys began only in the 1970s (Wooley and Mair 1977, Hawley et al. 1976, Brackett et al. 1982). The results of the surveys were not always satisfactory because of large standard errors of the estimates and large potential observer bias. Visual calving ground surveys were felt to underestimate numbers (Latour et al. 1986). Williams and Heard (pers. comm.) attempted a calving ground photo survey in 1983 which estimated 50-80,000 non-calf caribou.

In Alaska and the Yukon researchers have been able to survey herds by locating and photographing large aggregations of caribou in late June and July; and then counting the developed images. The post-calving photo survey has become the current method of choice particularly for the Porcupine herd but also for other Alaskan herds (Whitten 1985, Valkenburg et al. 1985).

Funding under the Northern Oil and Gas Action Program (NOGAP) of Indian and Northern Affairs Canada made it possible to capture and collar caribou in 1985 and test the feasibility of a post-calving photo survey of the Bluenose herd in July 1986. Funding for

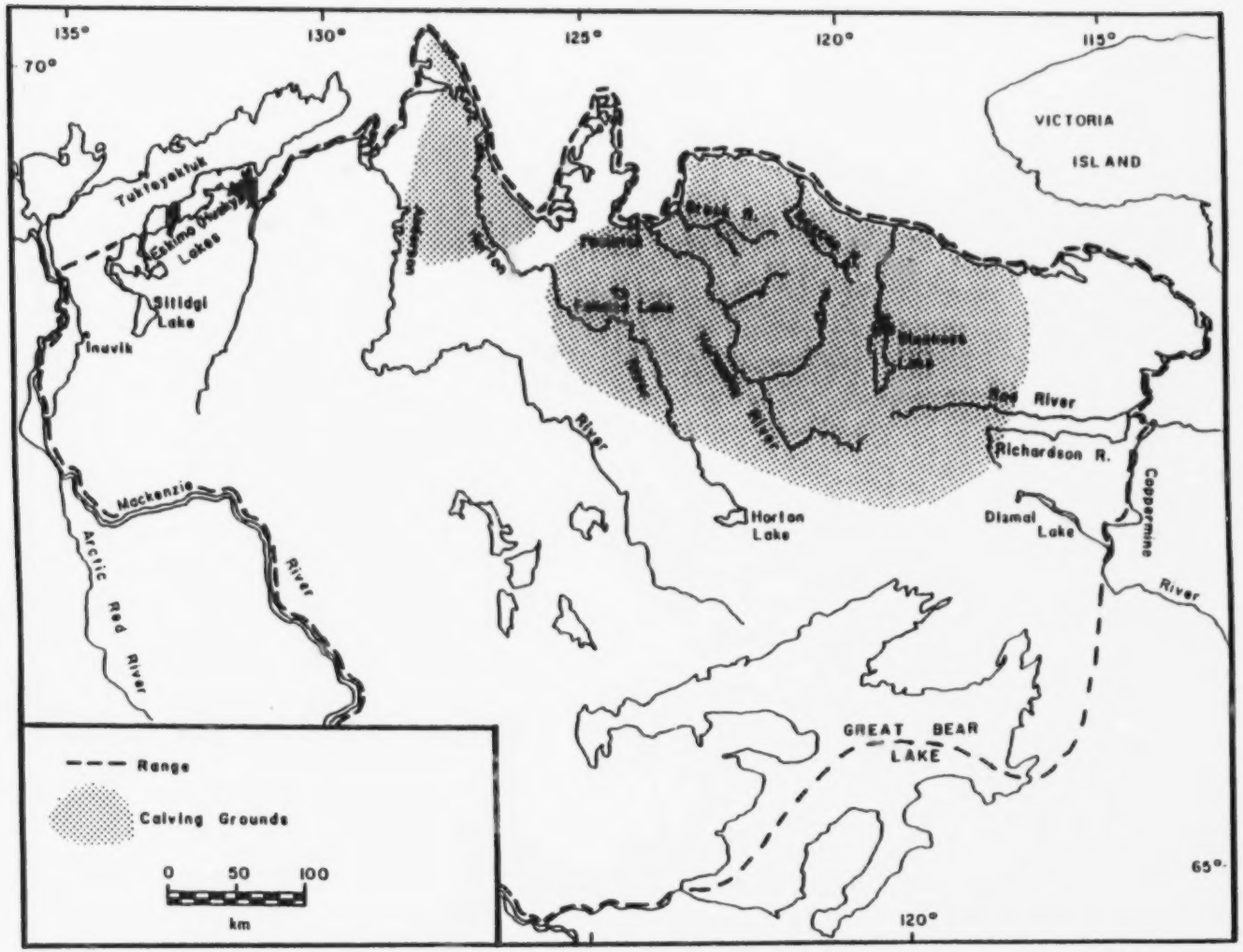

Figure 1. Range of Bluenose caribou in the NWT

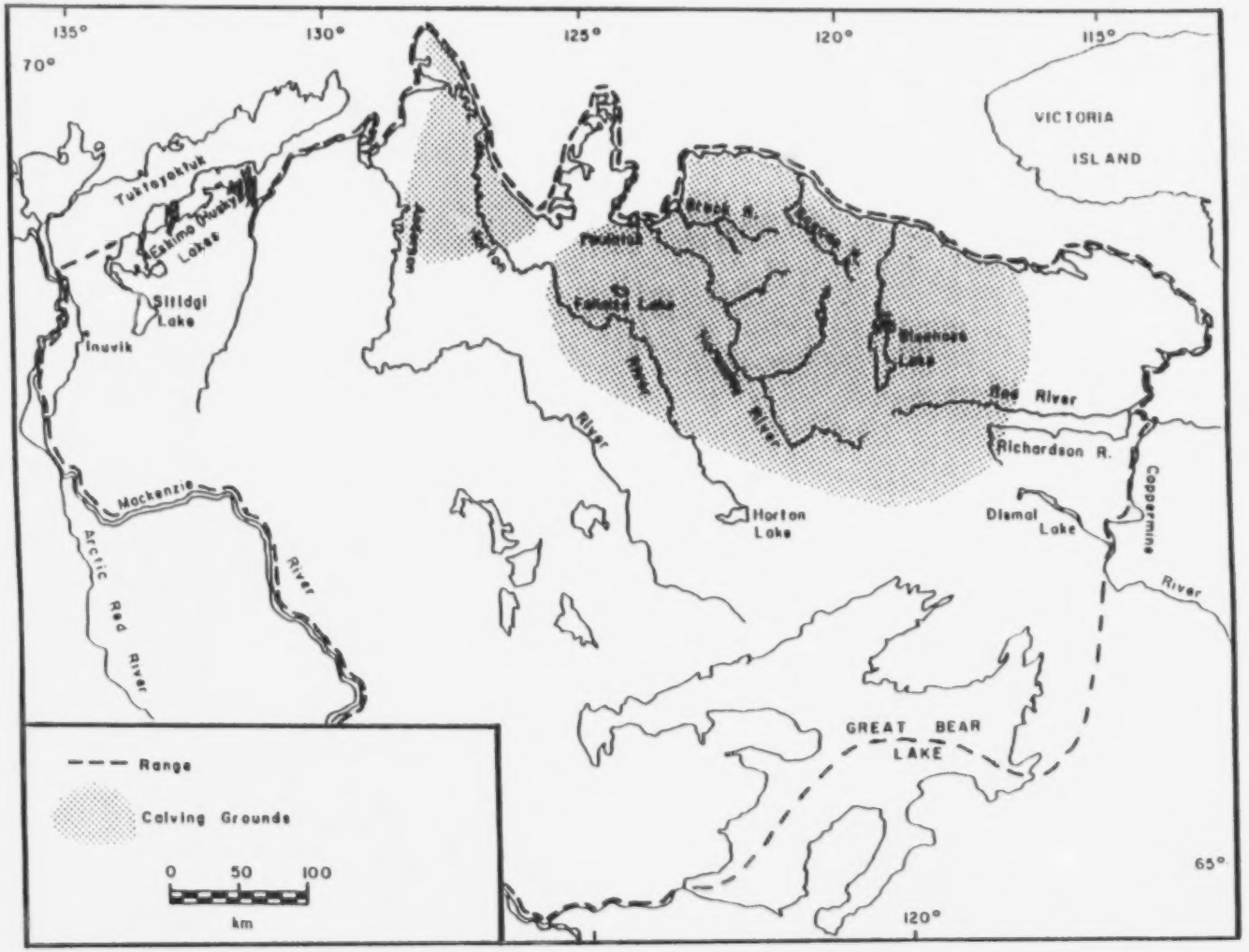

Figure 1. Range of Bluenose caribou in the NWT

the July 1987 survey was made available through the Inuvialuit Implementation Wildlife Studies program, administered and conducted by the Government of the NWT on behalf of the Inuvialuit.

METHODS

Caribou groups were monitored each day (except during bad weather) from 29 June - 14 July 1986, and 3 - 15 July 1987 by locating radio-collared caribou with a Cessna 185 aircraft and radio-tracking equipment. The starting dates were chosen based on census dates from the Porcupine herd (Russell pers. comm.) and other Bluenose work (Heard and Williams pers. comm., Carruthers and Jakimchuk 1981) when the aggregations were most likely to occur. Radio-collars had been placed on 30 adult cows in November 1985, 5 young bulls and 5 yearling females in March 1986, and on 11 female calves and 3 bulls in March 1987. While groups containing radio-collared caribou were being located, we scanned the terrain for other groups, using binoculars when needed. When groups were found that were gathered into a tight enough formation, they were photographed. Such groups were no more than 2 kilometers wide to ensure animals in the background would be visible on the photos, but there was no limit to length.

Cameras used were three 35mm single-lens reflex equipped with normal 50 mm lenses, motor drives and through-the-lens automatic light metering. Color transparency films with ASA ratings of 64, 100 and 400 were used. The photographs were taken at an oblique angle from the side windows of the aircraft which was 150 to 300 meters above ground level, slightly back from the near edge of the group and between the sun and the caribou to ensure good contrast. Two cameras were necessary, while a third was kept on hand as a spare. Two cameras provided for continuous exposure since one observer could reload while the other photographed. The camera in

use was tilted up and down and fired often enough to ensure complete coverage of the entire group, with 10 - 25% frame overlap. The shutter speed used was 1/250 second or faster. The time between frames averaged about one second; therefore, minimal movement of animals occurred. Only one pass was required to photograph an entire group. The speed of this method ensured that there was minimal error caused by caribou crossing overlap lines.

Each group photographed was given a number, marked on a 1:250,000 scale map and noted as to roll number, frame number, radio-collars present and any comments deemed necessary for further reference, either on tape, a fieldbook or both.

The monitoring of radio-collared caribou allowed the observers to assess the degree of aggregation, and note the amount of movement of groups from day to day. A photo survey is most likely to succeed where group size is large and the probability of groups without radio-collars is small. If we found small scattered groups when monitoring we checked only a few collars and waited for better conditions.

Counting caribou images and photographs

The slides were projected onto a 21.5 by 28 cm sheet of white paper placed about 45 centimetres from the projector lens. Overlap lines were drawn between landmarks common to adjacent slides. All images between the overlap lines interpreted as those of caribou were then counted by marking each image with a pencilled dot and pressing a tally machine. A magnifying glass was usually necessary to count animals clearly. Calves were the only distinguishable age class on the slides, so whenever a calf image was marked a second tally counter was activated. The counting of each slide resulted therefore in two numbers, one for caribou aged one year and older and one for calves approximately one month old.

The marking of each image with a pencil produced a hard copy of the interpretation and count that could be filed with the slides and compared to similar marks made by another observer, since the resulting dots always occur in a distinguishable pattern, thus allowing the dots corresponding to the same caribou image to be located. In this way it is possible to determine how many dots on each of the two counts do not match the other. The observers can then refer back to the slide and determine if unmatched dots refer to caribou not counted by one observer or to misinterpreted images and make appropriate corrections if necessary.

RESULTS

1986 Survey

The first survey flights in the area were made on June 29/86. At that time approximately 80% of the radio-collared caribou were located within 10 kilometers of the coast and from 25 km west of Paulatuk to 50 km east (Figure 2). However, they were too scattered to photograph. They soon began moving inland and by 4 July, were sufficiently aggregated for photography. At this point some groups were up to 40 km inland, near the south of Rummy Lake. They then largely stayed in distinct areas until 10 July. The caribou in the Mackenzie Lake area remained scattered until after 14 July when they finally aggregated enough to allow photographing. The areas used by different aggregations from west to east were as follows (see Figure 2):

1. North and west of the Horton River and Mackenzie Lake
2. South of Langton Bay
3. From Rummy Lake to 35 km. south
4. Near Hornaday Falls on the west side of the river
5. The area east of the Hornaday River.

When groups in one or more of the above areas were encountered in formations tight enough to photograph they were recorded on film. This resulted in groups in some areas being photographed several times. At project end on 15 July, 87 groups had been photographed on eight different days. It was necessary to count only 33 of these groups recorded on 4 of those days for a complete

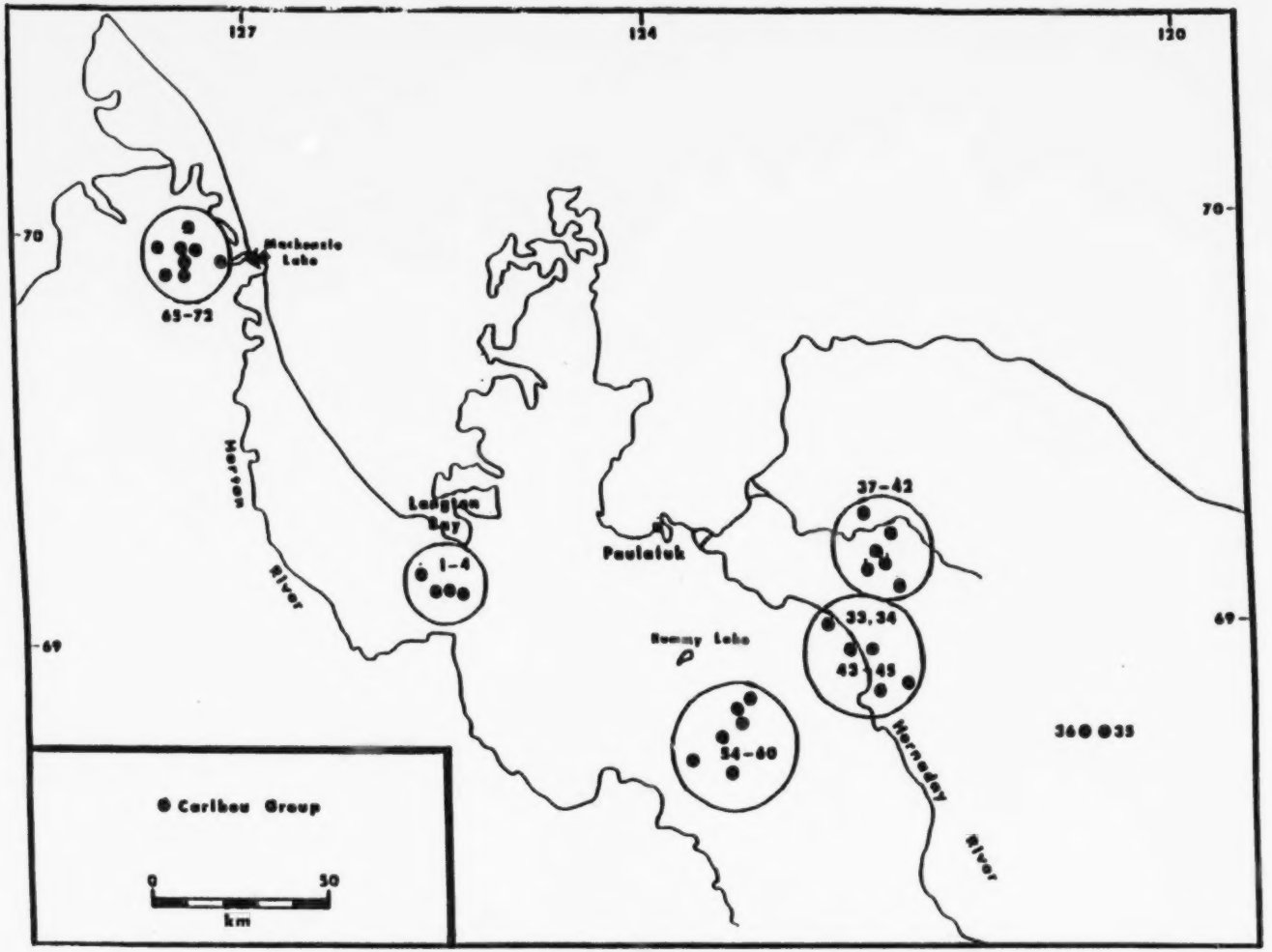

Figure 2. Locations of Bluenose caribou post-calving groups photographed in July 1986

count of the photographed portion of the herd.

A total of 96,936 non-calf caribou was counted by the first observer on the photos. The chronology of the areas counted can be seen in Table 1. A breakdown of the number of caribou on each slide is on file in the Inuvik office of Renewable Resources.

The slides of several groups were recounted by a second observer (B.M.) and a comparison of the counts made (Table 2). There was a difference of approximately 3-10% (non-calves) on individual groups compared (Table 2) and an overall difference for all groups counted of about 4% higher (non-calves) for H.J.R. than B.M. This could potentially lower the estimate by about 3500 animals. There was a much greater difference in the number of calves counted and one observer (B.M.) was less confident in distinguishing calves. In oblique photographs the animals in the background are much smaller and more difficult to see.

Two radio-collared caribou from photographed groups were observed to move near other areas. Caribou 33B moved from Langton Bay area to within 30 km. of the nearest Rummy Lake groups on July 9, before looping back northwest and further away from them. 21B was observed to move from the Rummy Lake area to Hornaday Falls on July 7 and, therefore, was only 15 - 20 km from groups 25 and 27. We know of no interchange of animals from one area (group) to another between the days on which they were counted.

Table 1. Radio-collared caribou and number of caribou counted in each group photographed between 4-15 July, 1986 in the Bluenose herd near Paulatuk, NWT.

Date	Group No.	#Radioed Caribou	Adults	Calves	(%)	Area
04/07	1	2	2,251	691	23.5	Langton Bay
"	2	None	1,622	474	22.6	"
"	3	1	1,888	542	22.3	"
"	4	2	5,166	1,954	27.4	"
"	5	2	19,786	545	2.7	"
07/07	33	4	4,658	1,856	28.5	E. Hornaday R.
"	34	2	2,729	1,086	28.4	"
"	35	1	2,250	440	16.4	"
"	36	1	278	115	29.3	"
"	37	1	1,437	536	27.2	"
"	38	1	888	267	23.1	"
"	39	None	814	258	24.1	"
"	40	1	2,718	910	25.1	"
"	41a	None	1,041	231	18.1	"
"	42	None	574	207	26.5	"
07/07	43	1	1,136	402	26.1	Hornaday Falls
"	44	None	831	414	33.3	"
"	45	None	1,276	509	28.5	"
09/07	54	2	4,622	983	17.5	Rummy Lake
"	55	None	1,763	308	14.9	"
"	56	None	1,341	394	22.7	"
"	57	2	3,646	741	16.9	"
"	58	None	490	64	11.6	"
"	59	9	16,703	5,783	25.7	"
"	60	1	3,552	753	17.5	"
14/07	65	1	1,435	109	7.1	Mackenzie Lake
"	66	None	1,415	206	12.1	"
"	67	None	440	101	18.7	"
"	68	1	1,971	530	21.2	"
"	69	None	1,493	116	7.2	"
	70b	None	2,716	727	21.1	"
"	71	1	2,108	617	22.6	"
"	72	None	1,898	368	16.2	"
Total			96,936	23,237	19.3	

a. 60 unphotographed caribou were added to the adult column
b. 55 caribou in this group were not photographed but noted and added to the adult column

Table 2. A comparison of counts between observers of post-calving photos, July 1986.

GROUP #	ADULTS		CALVES	TOTAL	OBSERVER
34	2,729		1,086	3,815	J.R.
34	3,061		339	3,400	B.M.
5	18,892		545	19,437	J.R.
5	17,821		34	17,855	B.M.
1	2,251		691	2,942	J.R.
1	2,103		31	2,134	B.M.
36	278		115	393	J.R.
36	269		57	326	B.M.
41 (6)	55		13	68	J.R.
41 (6)	53		11	64	B.M.
Total	24,205	(+898)			J.R.
	23,307				B.M.

1987 Survey

In 1987 the survey started on 3 July with tracking flights to locate the radio-collared caribou and assess the degree of aggregation. The weather deteriorated on 4 July but had improved by 7 July. Suitable aggregations started to form on 8 July (Appendix D). As in 1986, the caribou were distributed over a large area (Figure 3). The largest aggregations (most suitable for photos) were observed on 9,10 and 11 July. A large bull group (Group # 16) was photographed on 9 July and again on 11 July. The count on 11 July for this group was approximately 9,000 animals higher than on 9 July. All other groups were photographed once only on either 9 or 10 July. Twenty-four groups were located and photographed. Animals in the Bathurst Peninsula area did not aggregate suitably for photography, although the number of caribou was visually estimated (2500).

A total of 115,240 non-calf caribou was counted on the slides (Table 3). The frame numbers and the respective number of caribou counted are on file at the Inuvik office of Renewable Resources. Some of the slides were counted by both authors in 1987 (Table 4). There was an overall difference of less than 2% (1.3%) in the non-calf counts. As in 1986 there was a larger difference in calf numbers counted.

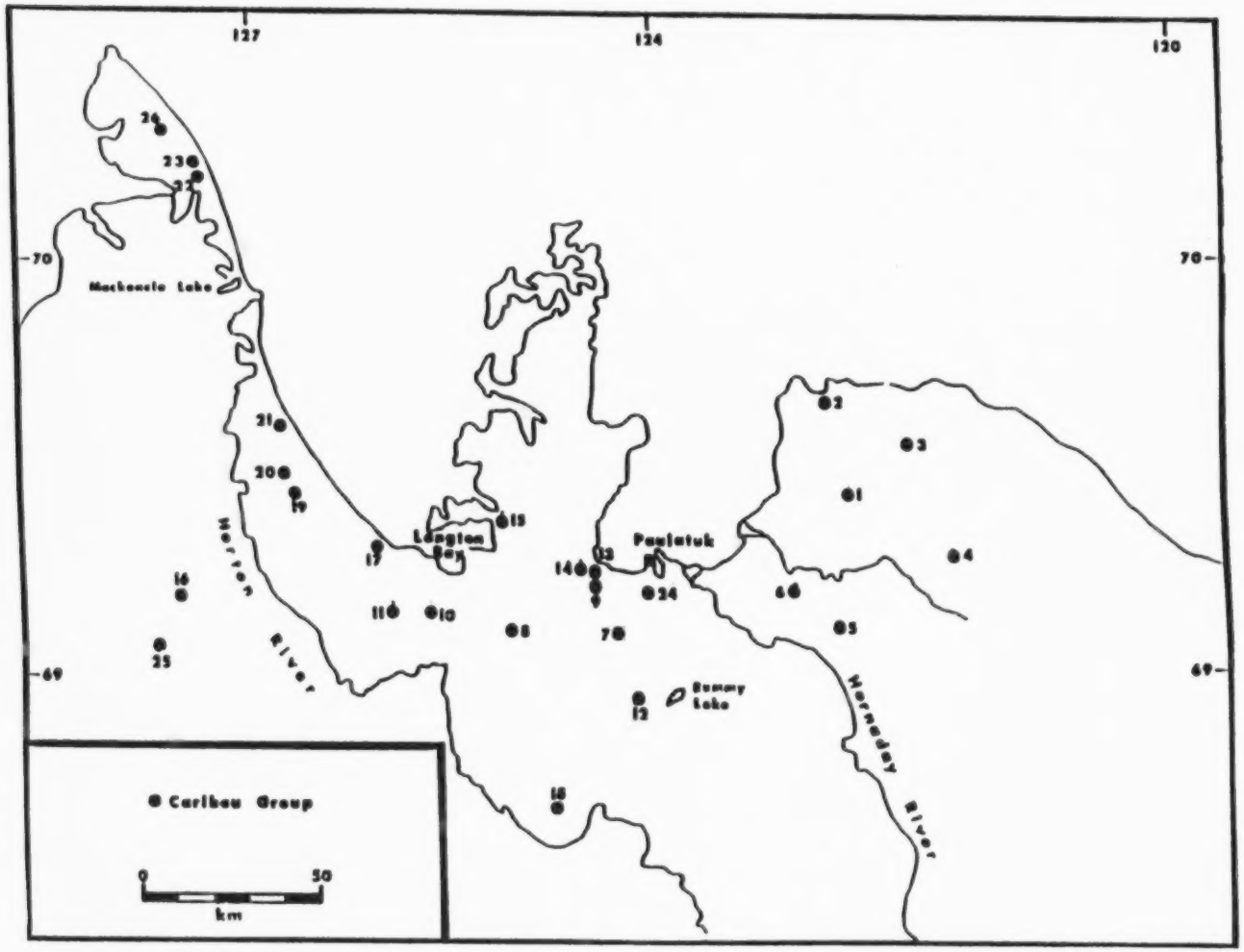

Figure 3. Locations of Bluenose caribou post-calving groups photographed in July 1987

Table 3. Caribou counted in each group photographed 9-11 July, 1987 in the Bluenose herd near Paulatuk, NWT.

Date	Group No.	# Radio Collars	Adults	Calves	Percentage Calves
9 July	1	1	616	32	5.2
	2	1	2,273	261	9.5
	3	1	555	102	18.4
	4	2	1,479	39	2.6
	5	1	160	34	21.3
	6	1	4,054	1,052	25.9
	7	4	2,763	552	20.0
	8	6	6,923	708	10.2
	9	none	2,226	403	18.1
	10	5	16,592	4,453	26.8
	11	7	15,178	3,566	23.5
	12	1	1,110	275	20.0
	13	1	2,795	349	11.1
	14	none	2,215	272	10.9
	15	1	2,815	227	8.1
	17	1	7,732	2,500	32.3
	18	1	942	219	23.2
10 July	19	1	3,445	180	5.2
	20	3	7,014	682	9.7
	21	1	1,047	97	9.3
	22	2	5,720	615	12.0
	23	none	1,461	509	34.8
	24	1	782	173	22.1
	26	2	2,500		no photos
11 July	25[a]	4	22,843	712	3.1
Total			115,240	18,012	13.8
July 9	16[a]	4	13,929	494	3.5

a) Group photographed on two different days.

Table 4. A comparison of caribou counts between observers of the post-calving aggregation photos, July 1987.

Roll No.	Frame No.	Adults	Calves	Observer
5	1	111	9	J.R.
		117	0	B.M.
5	2	231	47	J.R.
		248	20	B.M.
5	3	247	111	J.R.
		251	12	B.M.
5	5	460	130	J.R.
		477	15	B.M.
5	10	41	13	J.R.
		39	9	B.M.
5	15	32	6	J.R.
		32	5	B.M.
5	20	87	23	J.R.
		79	9	B.M.
5	25	268	65	J.R.
		263	26	B.M.
5	35	82	47	J.R.
		86	31	B.M.
5	37	102	31	J.R.
		94	27	B.M.
4	9	193	53	J.R.
		212	27	B.M.
6	2	65	17	J.R.
		71	9	B.M.
6	13	240	58	J.R.
		232	2	B.M.
6	17	153	50	J.R.
		160	34	B.M.
4	13	371	133	J.R.
		371	89	B.M.
4	22	2,077	551	J.R.
		2,089	25	B.M.
			1344	J.R.
			340	B.M.
Total		4,760		J.R.
		4,821 (+61 or 1.3%)		B.M.

DISCUSSION

The surveying of large migratory caribou herds has been a difficult problem and has often lead to estimates whose accuracy and precision were difficult to interpret. In an effort to improve census techniques, the post-calving photo survey has been developed and is used extensively in Alaska and the Yukon (Porcupine herd). Some years as much as 99 percent of the estimated population gathers into aggregations and is photographed (Whitten and Cameron 1980).

The two Bluenose caribou photo surveys in 1986 and 1987 gave a much higher, and hopefully more accurate, estimate of the population size than previous surveys. Although the photo method gives a direct count several biases affect the accuracy of the estimate. Table 5 summarizes which factors would increase or decrease the population estimate. A factor which underestimates the numbers present would mean our estimate is conservative. We are unable to quantify these biases but feel that animals not found were the most significant source of error.

Table 5. The 1986 and 1987 Bluenose population estimates and factors which influence the estimates.

	Estimate	# of groups	Effect on population estimate: Photo inter-pretive error	Groups missed	Double counting
1986	99,400	33	HJR 4% higher than BM Overestimate #	High chance Underestimate	Moderate chance Overestimate #'s
1987	115,200	27	HJR 2% higher than BM Overestimate #	Moderate Underestimate	Low chance Overestimate #'s

Valkenburg et al. (1985) recommended three conditions for a successful radio search photo survey (where all animals are surveyed):

1) radio-collars must be randomly distributed;

2) caribou must be grouped during surveying and the number of groups is not large compared with the number of radio-collared individuals; and

3) all radio-collars must be heard and precisely located.

To assess the success of the photosurveys, these conditions as well as two additional factors were examined; namely the possibility of double counting and photo-interpretive error. The 1986 and 1987 surveys satisfy these conditions with some qualifications about the degree of randomness.

The radio-collars in the Bluenose herd are unlikely to be

completely representative as the majority were placed on adult females with only 4 bulls having functional collars in 1986 and 5 in 1987. This could mean that part of the bull component of the herd was not found and, therefore, was underestimated. As we do not have the composition of the groups or know the adult sex ratio, we cannot determine the applicability this possible bias.

To determine whether or not there was a relationship between group size and the number of collars (regardless of sex), we compared the observed versus expected number of radio-collared caribou among the groups located during the census. The expected number was based on the mean number of caribou per radio collar, from the census total. The results suggest that the number of radio-collars per group was random in 1986 (Appendix A), chi square = 8.72, chi-^{2} (.05,df = 10) = 18.57 ; and in 1987 (Appendix B), chi square = 16.978, chi-^{2} (.05,df = 13) = 22.362. In 1986 the number of caribou per radio collar was 2617 while in 1987 it was 2400. The average size of groups photographed was larger in 1987 (4600 vs 2900), and there were fewer groups (27 versus 33 groups).

In both years the aggregations were suitable for photographing with some large groups containing up to 20,000. All caribou did not aggregate in the same area or on the same date, however. In 1986 some large groups were located which did not have radio-collared individuals (e.g., GRP 70), while other collared groups had only a few hundred animals (GRP 36). This suggests that groups without radio-collared caribou in them could have been missed. Using the 1987 data and calculations based on Valkenburg et al.

(1985), there is theoretically an 86% probability of a group of 4600 caribou (1987 mean group size) having at least one radio-collar. It is unlikely that there were many groups that large that were not surveyed. Smaller groups of hundreds or 1-2,000 could easily be missed. We did not attempt a systematic survey of the rest of the summer range during our survey and cannot quantify the bias of missed animals. To do so would have increased the survey costs. During survey of four Alaskan herds, 87 to 90 percent of caribou found by extensive visual search involving several aircraft would have been located using radio-search technique alone (Valkenburg et al. 1985). They also found in Alaska that the number of animals per radio collar and group size is quite variable among herds.

Small groups of caribou have been reported in the Dismal Lakes area both years during the census. We do not have an accurate estimate of numbers, but in 1986 it may have been up to a few thousand (Norm MacLean pers. comm.). Small numbers of caribou undoubtedly spend the summer on the parts of the range, e.g., bull 34BM was near the mouth of the Anderson River during July 1987.

Our radio-tracking information indicates that there was no crossover among groups photographed and that all collars were accounted for (3 of the 41 animals collared had died) in 1986. This greatly reduces the potential for double counting of groups photographed on different days.

The photos in 1987 were taken on two successive days in different areas except for the large bull group (#16- 9 July, #25-

11 July). Based on the collar locations there was no possible overlap among groups photographed on 9 and 10 July. The difference in the counts of the large bull group (13,900 on 9 July and 22,800 on 11 July) is more difficult to explain. The photographs are better on 11 July and the group was more aggregated. Possibly animals were missed in the immediate area on 9 July. As well, those photos were slightly overexposed. The other photographed groups were still more than 50 km away and did not add to this group (based on collared individuals). A recount of Group 25 by a third observer (L.G.) gave a count of 23,000. If the 9 July count is used, the herd estimate would be reduced to 106,300 non-calf caribou. Forty-eight radio-collars were accounted for in 1987, 1 bull was located far to the west in other work and was likely solitary or in a very small group, and 1 additional cow was not located.

The 1986 and 1987 photo estimates are higher than the 1982 photo estimate of 50-80,000 non-calves (Williams and Heard pers. comm.) A visual calving ground survey in 1983 estimated only 33,500 $\pm$ 14,300 in the herd (Latour et al. 1986). Caribou composition surveys in March 1983 (Williams and Elliott 1985), 1986, 1987 (McLean and Heard 1988), and 1988 (McLean and Jackson in prep.) indicated good potential recruitment of 44 $\pm$ 2.0 (SE); 55 $\pm$ 2.5 (SE); 42 $\pm$ 3.1 (SE) and 55 $\pm$ 4.8 (SD) (2 samples); and 45.9 $\pm$ 0.61 (SE) calves per 100 cows, respectively. These data would suggest high calf survivorship over their first winter, high potential recruitment and consequently an increasing herd size.

The general trend amongst other NWT barren-ground caribou herds has been towards increasing numbers in recent years (Heard pers. comm.).

The 1987 estimate was higher than the 1986 estimate. The greater number of collars operating in 1987 (49 vs 38 in 1986) assisted in finding groups of caribou which might otherwise have been missed. This would increase the estimate. Growth of the herd may also account for the higher count in 1987. Allowing for potential photo-interpretive error and missed animals, the Bluenose herd is certainly in excess of 100,000 and may even exceed our 1987 estimate of 115,200 non-calf caribou.

Future surveys

Ideally wildlife populations should be monitored often enough and precisely enough to establish rates of increase. Unfortunately agencies can seldom afford to survey large caribou herds more often than every 3 or 4 years. This increases the potential for a delay in detecting a change in trends. In the NWT we combine annual spring recruitment counts, which help establish a population trend in those years without a census, with a census every 3 years.

The majority of the existing collars will start to go off the air by winter 1988-89 (3 yr lifespan) leaving 10-20 collars which may or may not still be operational by June 1989. That would be too few collars to be confident of a successful survey. A post-calving photo survey would not be feasible without collars unless 2-3

aircraft were used to monitor movements of caribou continually. This would be as expensive as collaring and require potentially more manpower and aircraft. Our current methods cost approximately $50,000 for the photo survey and $30,000 for the collars and their placement on caribou.

To conduct a calving ground photo survey, as done in other parts of the NWT, a minimum of $80,000 (current costs) would be spent on the survey and it would be difficult to compare with previous Bluenose caribou estimates. Calving ground surveys estimate numbers of breeding females which is an index to total numbers and useful for establishing trends rather than an actual population estimate (Heard 1985). Without additional new data certain assumptions must be made about the proportion of reproductive age females, the proportion of those females that breed in the population and the adult sex ratio. We feel that the post-calving photo survey technique is preferrable to the calving ground census for the Bluenose herd.

CONCLUSIONS

The Bluenose herd either has increased substantially or previous survey methods underestimated herd size. Our estimate from the post-calving photo survey of 99,400 non-calf caribou in 1986 and 115,200 in 1987 was substantially higher than previous estimates. Potential sources of error in the estimate include double counting (if animals moved during photos), animals not found, and photo-interpretive error. The number of animals missed was likely the largest source of bias and consequently we feel that the estimate is conservative. The post-calving photo survey technique appears to be a cost effective and reliable census technique for the Bluenose herd.

Recommendations

1) A post-calving photo survey should be attempted in early July 1990; monitoring of collars should start no later than 28 June.
2) In order to attempt the survey, 25-30 additional collars should be placed on Bluenose caribou by March 1990; some of the collars should be placed on bulls and some (up to 10) on animals in the Coppermine area to spread out the placement of collars and ensure that that component of the herd is represented.
3) The next post-calving photo survey should be done with an aircraft capable of taking vertical photos (belly camera hatch) as well as oblique photos. A comparison would be done between the two

types of photography.

4) A second aircraft (C-185 type) should be available to search for outlying groups and take oblique photos.

Editorial note:

A post-calving photo survey was attempted in July 1991 but was cancelled due to prolonged cold weather. Eighteen caribou were collared in November 1990, east of Inuvik, in preparation for this survey.

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Appendix A. Distribution of 38 radio-collared caribou among post-calving aggregations of the Bluenose herd during a photo census July 4 to 14, 1986 (excluding calves).

Group No.	Group Size	Number of radio-collared caribou in group	Expected number of radio-collared caribou in group
1	2,251 a	2	0.9
2	1,622 a	0	0.6
3	1,888 a	1	0.7
4	5,166	2	2.0
5a	19,786	2	7.6
33	4,658 a	4	1.8
34	2,729 a	2	1.0
35	2,250 a	1	0.9
36	278 a	1	0.8
37	1,437 a	1	0.5
38	888 a	1	0.3
39	814 a	0	0.3
40	2,718 a	1	1.0
41	1,041 a	0	0.4
42	574 a	1	0.2
43	1,136 a	0	0.4
44	831 a	0	0.3
45	1,276 a	0	0.5
54	4,622 a	2	1.8
55	1,763 a	0	0.7
56	1,341 a	0	0.5
57	3,646 a	2	1.4
58	490 a	0	0.2
59	16,703	9	6.4
60	3,552 a	1	1.4
65	1,435 a	1	0.5
66	1,415 a	0	0.5
67	440 a	0	0.2
68	1,971 a	1	0.8
69	1,493 a	0	0.6
70	2,716 a	0	1.0
71	2,108 a	1	0.8
72	1,898 a	0	0.7
b	500 a	1	0.2
b	2,000 a	1	0.8
Total	99,436	38	38.6

Number of caribou per radio collar = 2,617

a. For Chi-square all groups smaller than 10,000 were combined
chi-^{2} = 7.69
^{n} = 5 - 1 = 4 d.f.
^{c}hi-^{2} 0.5,4 d.f. = 9.488; Accept H_0, No significant difference
b. Group not photographed but estimated.

Appendix B. Distribution of 48 radio-collared caribou among postcalving aggregations of the Bluenose herd during a photo census July 9 to 11, 1987.

Group	Group Size	No. of radio-collared caribou in group	Expected No. collared caribou in group
1.	616 b	1	0.3
2.	2,751	1	1.1
3.	555 b	1	0.2
4.	1,479 b	2	0.6
5.	160 b	1	0.1
6.	4,054	1	1.7
7.	2,763	4	1.1
8.	6,923	5	2.9
9.	2,226 b	0	0.9
10.	16,592	6	6.8
11.	15,178	7	6.3
12.	1,981 b	1	0.8
13.	2,539	1	1.0
14.	2,215 b	0	0.9
15.	2,815	1	1.2
17.	7,732	1	3.2
18.	942 b	1	0.4
19.	3,445	1	1.4
20.	7,014	3	2.9
21.	1,047 b	1	0.4
22.	5,747	2	2.4
23.	1,461 b	0	0.6
24.	782 b	1	0.3
25.	22,843	4	9.4
26.	2,500 a	2	1.0
Total	115,240	48	47.9

a. Visually estimated, not counted from photos.
b. For Chi-square analysis groups less than 2400 were combined chi^{-2} = 7.69; chi^{-2} (.05,df = 4) = 9.488; No significant difference, accept Ho.

Appendix C. Post-calving photo survey field schedule, 29 June - 15 July 1986.

Date	Weather	Activity
29/06	Warm, 20°C, wind light, cumulus	Initial recon, loose groups
30/06	Cooler, rain squalls	Caribou scattered
01/07	Fog, weather poor	Caribou scattered
02/07	Fog in morning, improving later	Loose aggregations
03/07	Fog persisting, weather cool	Loose aggregations
04/07	Sunny, warm, 10°C, wind light	First aggregations forming
05/07	Sunny, warm, 10°C, wind light	Aggregations in some areas
06/07	Sunny, 20°c inland, windy in PM	Aggregations
07/07	Sunny, 20°C, warm, buggy	Large aggregations
08/07	Sunny, 20°C, warm, smoke in air	Aggregations
09/07	Cooler, 15°C.	All photos, except Bathurst P.
10/07	Early fog, smoke haze, 10°C	No new aggregations
11-13	Back in Inuvik	Review results, waiting for Bathurst Peninsula grouping
14/07	High cloud, 15°C, windy	Photos in Bathurst Peninsula
15/07	Sunny, 15°C, light wind	Aggregations breaking up Return to Inuvik

Appendix D. Post-calving photo survey field schedule, 3-15 July 1987.

Date	Weather	Activity
03/07	Scattered, 15°C, light wind	Loose groups, tracking
04/07	Weather out, fog, drizzle	Small groups, 33BM only
05/07	Weather still poor, overcast	Small groups
06/07	Low cloud, 2°C, light wind	Groups 1-2,000 scattered
07/07	CAVU, 10°C, light wind	Aggregation S. Paulutuk
08/07	CAVU, 10-15°C, light wind	Aggregations
09/07	CAVU, 15-20°C,	Photo aggregations
10/07	CAVU, 15+°C, light wind	Photo aggregations
11/07	CAVU, 15-20°C, south	Photo aggregations
12/07	High Cirrus, 15°C, west 10	Monitored group
13/07	Inuvik	Review results
14/07	Cirrus, cumulus, 15-20°C	Monitored groups
15/07	Overcast, 15°C, light wind	Monitored groups, finish